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ABSTRACT

This report summarizes the findings and recommendations of a feasibility study of industrialized building method utilization in school construction. The 3-part format attempts to define the conditions necessary for the satisfactory operation of an industrialized building system for the benefit of the community; explain the conditions relevant to the issues of system building which exist in British Columbia; and recommend what must be done in British Columbia to sponsor and sustain an industrialized building system for schools. In part one, description of the issues in principle is outlined and represents a summary of research undertaken in Europe, the U.S.A., and eastern Canada of four significant industrialized building systems. The findings of a market analysis, an examination of local manufacturing capabilities, and comments on the building codes and the need for a locally sponsored building system comprise part two. A summary of conclusions and recommendations and their rationale is set out in part three. Appendixes contain school construction costs and cost estimates, an analysis of construction types, and comments of the Metropolitan Toronto School Board Study of Educational Facilities progress to date with implications for a system building program in British Columbia. (Photographs may reproduce poorly.) (Author/MLF)

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Educational
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Institute of B.C.

The Feasibility of A Systems Building Programme For The Construction Of British Columbia Schools

Robin A. Clarke

EA 003 995

STUDIES & REPORTS

Report No 6

The Feasibility of A Systems Building Programme For The Construction Of British Columbia Schools

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December 1969.

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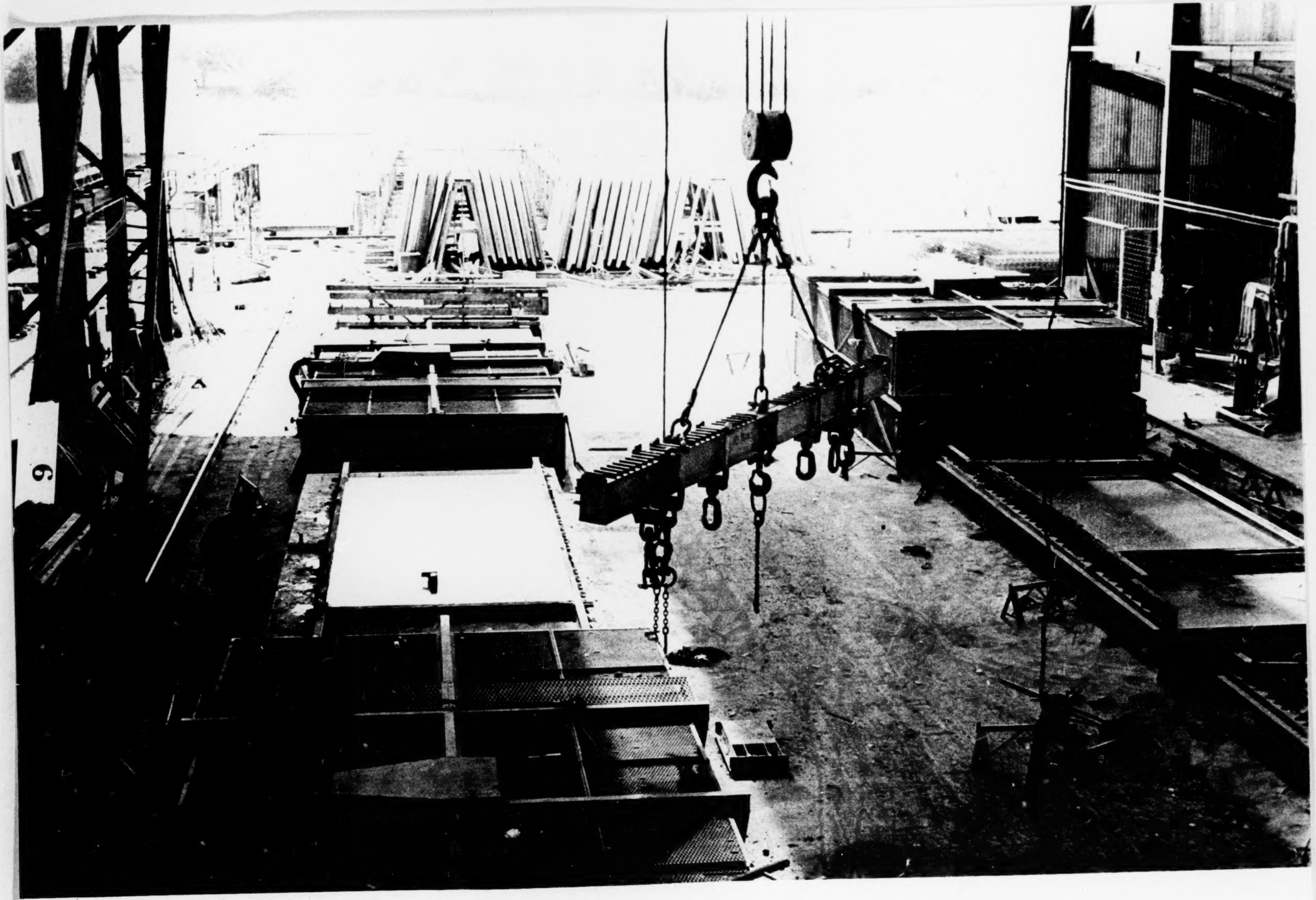


"TRACOBA" system (French). Regional pre-casting plant.

INTRODUCTION

The scope and format of the report

The abridged final report is the second part of the feasibility study undertaken to determine the means by which industrialized building methods can be used for the construction of schools in British Columbia. The interim report describes the evolution of system building, defines the problem, and the approach taken in this study to the problem. The final report presents a summary of findings and recommendations in a format which attempts to answer three fundamental questions:

QUESTION ONE: What are the conditions necessary for the satisfactory operation of an industrialized building system for the benefit of the community?

A description of the issues in principle is outlined and represents a summary of research undertaken in Europe, U.S.A. and eastern Canada of four significant industriliazed building systems: C.L.A.S.P., Consortium of Local Authorities Special Program, Nottingham; NENK, Ministry of Public Building and Works, England; S.C.S.D., School Construction System Development, California, U.S.A., and S.E.F., Study of Educational Facilities, Metropolitan Toronto.

There is a strong family resemblance between the first educational industrialized building system pioneered by Hertfordshire County Council in 1947 (now S. E. A. C.), the C. L. A. S. P. system 1955, NENK system 1960, S. C. S. D. 1961 and S. E. F. 1967. A brief history of industrialized building methods was included in the preliminary report with particular reference to the features of these systems. Comments upon the first Canadian open building system S. E. F. is included in the appendix of this report.

QUESTION TWO: What conditions relevant to the issues of system building exist in British Columbia?

The summary of findings of a market analysis, an examination of local manufacturing capabilities, together with a comment on the building codes and the need for a locally sponsored building system is presented in part two. The analysis of the provincial school building programme was undertaken with the generous co-operation of the Department of Education, Victoria. The assessment of province wide manufacturing capabilities is the product of extensive field trips to all major local building component manufacturers and was made possible by the generous co-operation of construction and manufacturers trade associations.

QUESTION THREE: What must be done in British Columbia to sponsor and sustain an industrialized building system for schools?

A summary of conclusions and recommendations, and the reasons for those recommendations is set out in section three.

Comment on the problem

You don't have to be an architect to realize that there are serious inadequacies in the present means of solving the community's building problems. The architectural profession has become the focus for criticism, which is really an expression of dissatisfaction with the quality and cost of the finished building. Unfortunately, the traditional client/architect relationship has perpetuated the profession as a product orientated group, whereas the root of the difficulties is due to the incomplete and fragmented nature of the building process. During the past sixty years traditional craft orientated construction methods have been supplemented in a limited way with new technologies, when the demand for building has justified a re-evaluation of the entire approach. Although the population increase has caused unprecedented urban growth an examination of the role of architecture in the community shows that the professional designer has lost control of the means of building. The relationships in the community have restricted the architect from extending his influence beyond the design of public buildings, and consequently his talents are utilized for only twelve per cent of the total volume of construction in Canada.

Why has this situation developed and what are the conditions which have prevented an evolutionary change to satisfy these new problems?

The building industry regards itself as a service industry, and the factors which have contributed to a low capital intensification or industrialization are outside the control of its individual members.

The general demand for an investment in new building tends to be cyclical by nature and individual clients have required space on a building by building basis. In order to retain a flexible response to these conditions on the site and in the factory the building industry has used methods with a limited investment in plant, and a high labour content in order to avoid a financial over-commitment. During a period of low demand, work crews can be laid off leaving a minimum of capital tied up in plant and machinery.

The lack of control and organization of the building process has major implications for a province like British Columbia where four-fifths of employment is directly or indirectly related to the building industry. The Honorable C.M. Drury, when he was Federal Minister of Industry said that productivity increases from 1961 until 1967 in terms of output per person employed, increased 21% in manufacturing industries, over 100% in agriculture, but only 6% in the construction industry. The increase of construction costs and the demand for space because of population growth has created a crisis in the building industry which is not being solved with traditional methods. The question is: is the most effective use of building resources occurring? not: will traditional building methods continue to be used?

The systems approach to building is a proven concept that can be utilized to solve the immediate problems of school building. However, the idea has broader implications for the building industry and the economic welfare of the community. It is a process orientated approach which provides the incentive and organization for the building industry to improve its methods to meet the building problems of a mass society. The systems approach embodies two fundamental concepts not possible with traditional methods.

Architectural hardware as a system: first it establishes the means of implementing greater industrialization in the building industry by stabilizing a market of sufficient volume to justify a greater capital intensification of methods. The concept improves construction techniques by utilizing factory made building components and rationalizing assembly operations.

The building process seen as a system: secondly, the volume of construction provides the opportunity and justification to monitor and control the building process by the use of contemporary management methods such as operational research techniques. The whole range of activities that occur before and during construction can be viewed as part of a total system of operations with a series of pre-determined goals. Consequently, the effect of one operation within the system upon another can be predicted and the outcome planned. The effects of modifying the inputs to the system can be predicted in terms of changed expectations. The characteristics of the system, that is its effectiveness as a model of reality, will be continually improved by feed-back from on-going experience. It is an intrinsically flexible approach which can adapt to new building requirements as social-economic conditions dictate. The systems approach to building changes the relationships between client, professional, contractor and manufacturer in order to achieve a more effective building team. However, the building industry alone cannot be expected to industrialize its processes or modify its methods if the construction market continues to exist as a series of fragmented and unrelated problems.

Activity elsewhere indicates that a more sophisticated attitude is being taken towards the problem of effective use of school building resources and productivity in the building industry. If the object of the exercise is to increase productivity by improving building technology, then you have to change existing relationships in the industry in order that improvements can occur. The incentive for improvement can be established by presenting a problem to industry that connot be solved by traditional methods. If the client-owner offers a substantial building programme for open bid, change and improvements are inevitable.

The response to this study by the building industry in British Columbia has been creative and co-operative. There are many benefits to the participants of a system building programme that do not exist with traditional building. Elsewhere in this report an assessment is made of existing capabilities, and it is possible to state that the local building industry has the capacity to handle a systems programme, and is willing to participate in the improvement of its methods. The legislative educational responsibilities and the status quo, indicates that it is the provincial government's privilege to take the first step towards co-ordinating the school construction programme. The administrative means of achieving consolidation must be regarded as a process orientated approach towards the ultimate social goals of the programme. The findings of this research programme confirm that the systems approach to building will make more effective use of the provincial school building resources if sponsorship occurs within the terms of reference set out in the recommendations of this report.

Summary of Recommendations

1. Rationalize and organize the demand for building

   The provincial government and the school trustees should organize an annual volume of construction in excess of $25 million into one building programme, by combining the school building requirements of the lower mainland with similar requirements, from other parts of the province.

2. Sponsorship of the building system

   - **The "client-owner" (the provincial government and school trustees) establish a provincial SCHOOL BUILDING CONSORTIUM as a fiscal and legal body to implement the phased approach to sponsorship of an industrialized building system as set out in this report, (part 3 - section 2).**
   - **The preparation of the client's requirements in terms of legal documents for public tender be undertaken by the client's RESEARCH DESIGN AND DEVELOPMENT GROUP, established as an autonomous organization outside existing educational institutions and directly responsible to the provincial SCHOOL BUILDING CONSORTIUM.**

3. Characteristics of the building system

   The best solution within the recommended market definition to the provincial school building requirements is to establish a

building system with two major characteristics:

i) An "open" building system to ensure the two way benefits of interchangeability with other Canadian systems.

ii) A system with the design characteristics capable of meeting urban and suburban building requirements - that is a system with the feature of interchangeability of architectural components of different materials within the system.

4. The rationalization of educational requirements

The analysis of educational requirements and preparation of educational specifications should occur in phase one of the process and be undertaken by staff educators and architects of the RESEARCH, DESIGN AND DEVELOPMENT GROUP in consultation with others.

5. The role of the professional designer

The most effective use of professional services will be achieved by redeploying talent set within new operating relationships in the building industry. These new relationships are established by the phased approach to sponsorship as set out in this report.

6. The re-bidding of the school component programme on a bi-annual basis

The requirements of the provincial SCHOOL BUILDING CONSORTIUM be organized into bi-annual programmes to be bid upon by individual manufacturers on the basis of an integrated "open" building system.

7. On site specialization and sub-system bidding procedures

On site specialization of assembly operations be encouraged by sub-system bidding contracts which require the design, development, supply and installation of building components or fulfillment of specific tasks as a package by one or a group of companies.

8. Organization for on-going management, administration, research, design and development

The combined tasks of on-going management, administration, research, design and development essential for the operation of the provincial SCHOOL BUILDING CONSORTIUM be undertaken by the client's RESEARCH, DESIGN AND DEVELOPMENT GROUP as the administrative control organization.

9. The Building Codes

. The industrialized building system developed for provincial school buildings be designed to comply with the principles of safety and construction standards of the National Building Code.

- A programme of liaison between municipalities and cities be initiated by the provincial government to promote the general adoption of the National Building Code, and its consistent application throughout the province.

"DERWENT" system. Stockpile of wood components.

PART I. DEFINITION OF ISSUES IN PRINCIPLE.

Question One: What are the conditions necessary for the satisfactory operation of an industrialized building system for the benefit of the community?

PART I. DEFINITION OF ISSUES IN PRINCIPLE

QUESTION ONE: What are the conditions necessary for the satisfactory operation of an industrialized building system for the benefit of the community?

1. The need for an adequate volume of construction

- The market demand for building space must be rationalized and administered to achieve a substantial annual volume of work which will provide the opportunity for manufacturers to modify their methods to achieve peak productivity.
- The individual building components which are elements of the building system will then be bid upon the basis of an assured substantial volume. The benefits will be passed on to the sponsor of the system.
- If a construction programme of sufficient volume is offered to industry new products designed specifically for one purpose can be developed at no direct cost to the sponsor. The opportunity for an assured flow of work will allow the manufacturer to write off development costs of the new product against the initial programme and potential future markets.
- The economies of scale can only apply to the total building programme and are not applicable to fragmented parts where architects have arrived at apparently similar, but not identical conclusions.

- The long term purpose of system building is to increase productivity in the building industry by creating a situation that will effect the gradual industrialization of building methods. Consequently the client's building programme must be offered to industry on a year to year basis.

2. The rationalization of user requirements

- The introduction of a system building programme to resolve a particular set of problems normally represents a significant point of change in the design and construction process from a fragmented to a comprehensive approach. The commitment to a programme of this scale allows and justifies the time and effort to undertake a comprehensive in depth analysis of user requirements. If the architectural requirements are determined in the conventional way, it may well mean that the prejudices of a few strong personalities will establish unrealistic and unfounded characteristics in the building system.
- The design of the building system must achieve a balance between the need for freedom and variety in planning, and the discipline of standardization for economic factory production. It follows that a definitive analysis of present and projected user activities and requirements must be undertaken in order to establish a basis for the problem.
- In the case of educational facilities, it is important to ensure that

an analysis of educational requirements occurs within the parameters of evolving educational theory and provincial policy so that predictions for future needs will be well founded.

3. Design and development with the participation of the building industry

- In order for a component manufacturer to reach peak productivity two considerations must be met:
  a) The building component must be designed with an intelligent appreciation of the manufacturing process, its potential and inherent limitations. Therefore mutual consultation between designer and manufacturer must occur initially.
  b) The range of components that the manufacturer can handle within the existing capability of his plant must be determined to ensure that bulk orders are achieving maximum economies.
- The problem of bulk buying of building components is one of shifting parameters. There is no absolute optimum size of programme only a working minimum. A manufacturer who has an assured market for three years will be prepared to invest capital in new machinery and write it off over that period. The increased industrialization will show economies to the buyer, whereas the manufacturer with an assured market for one year is likely to rationalize his production within existing investment in plant and pass on limited economies to the buyer.

- It is important to ensure that all levels of the building industry have an opportunity to contribute their ideas at appropriate times in order that change be effected with a maximum of co-operation between participants. This consideration refers to all participants and contributors to the building process and spans a range from the manufacturer and their trade associations to organized labour.

4. The case for open competition from time to time for major contracts of building components

The purposes of this condition must be largely self evident.

- It is not in the client's long term interests to provide a captive market for a few select companies. After an initial period of experience actual costs plus reasonable profit will be passed on to the client only if open competition for contracts continues to exist.

- The open systems approach exploits the opportunity available when re-bidding a programme to allow for the improvement or change of standards according to the dictates of experience and new requirements. In this way it is possible to ensure that the approach will generate a variety of design choices not previously associated with industrialized building.

5. The need for on-site specialization

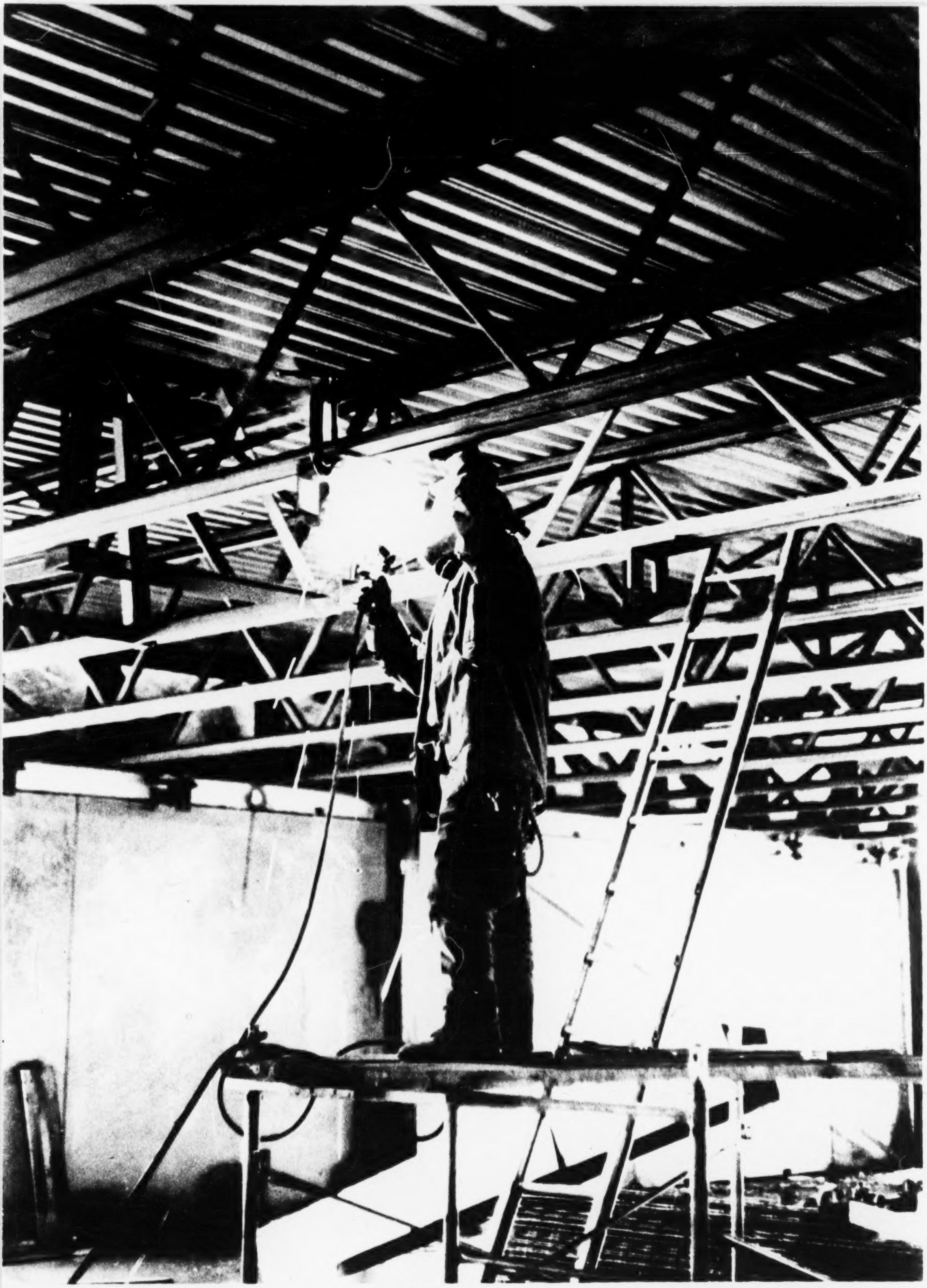
System building represents a unique opportunity for the improvement of organizational techniques and on-site building methods that it is not possible with traditional methods. It is important to create a situation where specialization can occur in general contracting and on site as well as in other areas of the industry. Assembly crews and other building operatives can be specially trained to benefit from the unique design features and repetition of system building methods. A further consideration is to ensure that the new resource of skilled operatives continue to participate in system building programmes.

- One method of effecting on site specialization is to organize sequential building starts into groups by school districts and to award serialized contracts for groups of schools to one general contractor. This approach is effective only so long as the general contractor continues to participate in system construction programmes.
- Another way of achieving on site specialization is by the use of sub-system bidding procedures which offer a series of related operations: i.e., design, develop, manufacture, supply and installation of a particular component, or the completion of a particular task as one contractual package. In this case the assembly crews will specialize as members of the suppliers' company and will continue to participate in systems programmes so long as the suppliers' products are used.

If opportunities and incentives are established for the specialization of managerial and operative skills the payoff will be immediate cost savings to the client and sustained long term increases in building productivity.

6. The purpose of on-going research and development

- The refinement and innovations that will occur at the manufacturing level and on site must be co-ordinated and directed by the sponsor to ensure that improvements are complementary and that an overall increase in productivity will result.
- The sponsor's ultimate welfare rests upon his ability to monitor and control the improvement of the whole building process towards his specific goals, (i.e., cost reduction, better quality, more space per dollar, greater variety, better use of labour, and so forth). Therefore, if improved productivity and the reduction of unit cost are a prime consideration, the day to day building process must be subject to continued research and development. Therefore, appropriate means must be used to assess all levels of the process from design through management to labour, in order to ensure that modifications of the approach are based upon factual evidence and that changes will in fact produce improvement.



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S.E.F. system. Field welding at the Roden School Toronto.

PART II. SUMMARY OF FINDINGS.

Question Two: What conditions relevant to the issues of system building exist in British Columbia?

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QUESTION TWO: What conditions relevant to the issues of system building exist in British Columbia?

1. The provincial school building programme

- Market analysis.

  How much and what kind of school building has occurred since 1960?

  i) Volume of provincial school construction classified by capital cost and geographic areas, 1960-68. See appendix - Item III.

  ii) Types of construction classified by building code categories, for the following areas:

  Lower regional mainland.
  Vancouver Island. See appendix - Item IV.

- Forecast of future school building requirements.

  a) The British Columbia Department of Education statistics: "Student increases 1937-67 and estimates to 1987".

  i) Elementary enrolment: a sharp decline in the rate of enrolment:

  from 1956-57 to 1966-67... 59% increase was recorded,

  whereas,

  from 1966-67 to 1976-77....4% increase is estimated.

  Economic Council of Canada Staff Study No. 20: comments on elementary enrolment in Canada.

- "Total enrolment is expected to rise up to 1970-71, but at a moderate rate of growth thereafter it is expected to decline up to 1975-76". *
- "This pattern of change is observed for all four variants based on the various fertility and immigration assumptions; the fertility assumption accounts for the major portion of difference between the four variants". *

ii) Secondary enrolment: the rate of growth is more than halved:

from 1956-57 to 1966-67...... 100% increase was recorded

whereas,

from 1966-67 to 1976-77...... 44% increase is estimated.

- "The rates of growth in secondary enrolment are substantially higher than the underlying growth of the relevant age groups. For the past 10 years, as well as for the coming 10 years, enrolment advanced about twice as rapidly as the number of persons in high school age groups. This is reflected in the sharp increases of high school participation rates". *
- "The fact that enrolment grew rapidly over the past 10 years, but is expected to grow more slowly from now on, is almost entirely due to changes in the underlying population. From

> 1955-1956 to 1965-66 the 14-17 population rose by about 60%, while enrolment rose by almost 140%. Over the coming 10 years the 14-17 is expected to rise by about 20%, with enrolment projected to rise by almost 40%". *

b) Comment upon existing school stock and rate of obsolescence:

- It might be reasonably assumed that existing school building stock becomes obsolescent after twenty years of use and is due for major interior renovation. School buildings in excess of forty years can be considered obsolete by current standards and consequently should be scheduled for replacement wherever possible.
- In 1925-26 school enrolment in British Columbia was 101,688 pupils. In 1966-67 the enrolment was 445,200 pupils. It is necessary to assume that the school building stock was adequate for both dates, although there are no records available to determine how much of the pre-1925 stock has been replaced over the past forty years. A conservative estimate suggests that 20% of the existing school buildings are more than forty years old.

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* Enrolment in Schools and Universities. . 1951-52 to 1975-76, by W. M. Illing and Z. E. Zsigmond. Staff Study No. 20. Economic Council of Canada 1967.

- A proportion of this stock must have been built in the lower mainland area, in which case increasing land costs will justify replacement as the original site utilization becomes unacceptable.

- It was not possible to establish a rate of obsolescence for existing schools, so that the rate of replacement of obsolete structures is not clear. However, if 20% of existing stock is forty years or older, the replacement of old buildings can now be expected to be greater in the next ten years than ever before.

2. The building component manufacturing industry in British Columbia

An examination of local capabilities to manufacture and fabricate building elements and components for a system building programme.

- The manufacturer's relationship to the building industry.

The relationships that exist within the building industry at the present time to satisfy the practices of traditional building place the manufacturer one step away from the critical decisions of component design. There are many aspects of the client's requirements that are not considered from the manufacturer's point of view, and generally speaking the traditional roles have created a situation where the manufacturer is unable to pass on the full benefits of mass production to the buyer. There were found to be two reasons for this: firstly, the very nature of traditional methods has meant that custom design buildings have required custom made components.... secondly, the considerations that are of prime importance to an efficient plant operation have been of minor concern to professionals engaged in meeting their client's needs. Design factors such as:

  - components detailed on preferred sets of dimension..
  - the economic use of material..
  - the consideration of assembly procedures as a design problem..
  - the design of the element with full knowledge of the production process... all have been low priorities to the designer.

- Current price structure.

The manufacturers of building components have to meet the demand for a high proportion of custom work that occurs with traditional construction methods. At the present time the cost saving achieved in substantial manufacturing runs of building components is absorbed by the custom work so that the economy of standardization is not reflected in the price structure.

- The economies of scale.

A comparative cost estimate was made for the structural assemblies of one typical 30,000 sq. ft. school purchased individually, and thirty at a time. (The lower mainland spent $16 million on buildings alone in 1967 which represents approximately 1 million square feet of school space). The bulk order would enable the manufacturer to reduce his unit costs for the following reasons:

- greater design time at the consultants and shop level show material saving of 10% (conservative estimate).
- 15% cost saving from bulk purchase of raw material.
- saving on shop drawings.
- 25% savings upon the on site erection, achieved by simplification of connection details, and specialization by assembly gangs.

  At an overall estimated saving to the purchaser completed and erected on site of 28%.

- It was found that the economies of scale differ according to the raw material and the nature of the manufacturing process. Processes that utilize hand labour and batch assembly procedures reached an optimum production rate sooner than those that were mechanized.
- The so-called "learning curve" differed in a comparison of local manufacturing and fabricating methods for major structural elements in concrete, steel and wood. It was found that the minimum size of order for the most efficient plant operation varied from $300,000.00 to $600,000.00 for a structural assembly of elements. These figures represent an optimum point on the learning curve and suggest that a minimum programme of approximately $10 million is necessary in order to exploit the present potential of local manufacturing capabilities. The existing capital

investment in plant was accepted as a parameter so that the comparison is relative to local conditions rather than a full expression of a particular materials adaptability to industrialized methods. It should also be noted that if a substantial contract were awarded on an assured basis, investment in new plant would be justified.

- The concern of the buyer is to establish the best cost rate for a quality product which meets his particular requirements. In the case of bulk purchase by a client consortium the size of the order will enable the buyer to insist upon certain modifications of existing products. The first concern is to purchase a series of compatible components, a building system which will satisfy the need for special variety in the finished building. This can be achieved by the modification of existing products or by the introduction of new products. However, the level of innovation in the product demanded by the buyer must be realistic, that is related to existing manufacturing capabilities and to the size of the order. If the requirements are set too high to be justified by the annual programme, there may be an initial apparent successful response for the first year, followed by a period of reassessment where the manufacturer may find that he is over committed. In this case production will cease, unless the manufacturer is prepared to accept a loss until such time as the volume of work justifies the original design.

The buyer's requirements must be expressed to achieve an optimum level of design innovation in the context of local manufacturing capabilities and the size of the annual building programme.

- Summary of findings

In general it was found that there is adequate capability within existing manufacturing and fabricating plants in the lower mainland to meet the technological and volume requirements of a school system building programme. The technical problem of producing compatible pre-fabricated building components is not seen as critical. The problems created by peak building activity at certain times of the year in excess of individual manufacturer monthly capacity must be met by advanced planning and stock piling of certain universal components. It is anticipated that certain specialized mechanical and electrical components may be manufactured elsewhere in which case the problem of modular co-ordination of the imported product must be solved.

3. The building codes

- The case for uniformity

The effective operation of a regionally based industrialized building system depends upon the uniformity and consistent interpretation of local building codes. The standardization of design details and building assemblies for a mass market cannot occur unless there is acceptance between municipalities of a comprehensive building code. If the continuity of design and production is interrupted because of the need to satisfy the unique requirements of a local code, the overall efficiency of the whole approach will be affected. Consequently, the building system should be designed to meet the principles of safety and construction established at a provincial or national level. It will then be possible to achieve a comprehensive application within a region and also to be reasonably sure that locally manufactured components will be accepted elsewhere in Canada.

- Local building codes and their interpretation.

It was found that there is no consistent pattern as to the content, requirements and interpretation of local building codes throughout the province. The National Building Code has been used as a model by a great number of municipalities and cities so that the general principles of safety that apply are similar in many cases. However, the practical application of local building codes reflects very little overall consistency of requirement or interpretation.

Two recommendations:

One: The industrialized building system developed for provincial school buildings be designed to comply with the principles of safety and construction standards of the National Building Code.

Two: A programme of liaison between municipalities and cities be initiated by the provincial government to promote the general adoption of the 1970 edition of the National Building Code and its consistent application throughout the province.

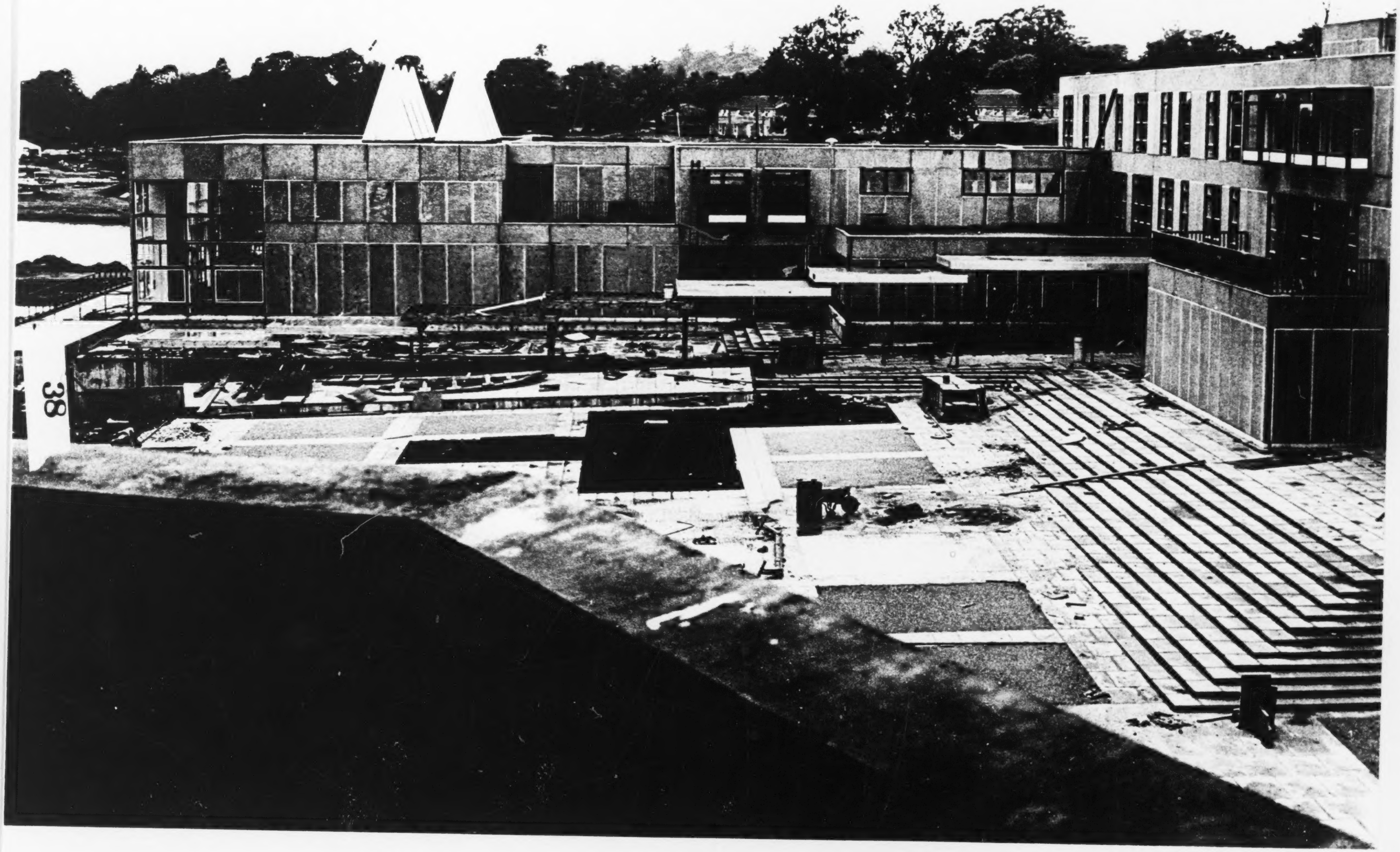
As an interim measure to assure the immediate acceptance of a systems building programme, the examination of the possibility of legal exemption from certain local code resistrictions for buildings provincially or publicly owned.

4. The need for a building system designed, developed and manufactured in British Columbia

It was found that there are many reasons beyond the effective solution of the school building problem that justify the sponsorship of a building system manufactured in British Columbia.

- The industrialized building system offers the owner-client an alternative means of construction which is known to be more effective than traditional building. The competition will have the effect of improving methods of on site building with an overall increase in productivity throughout the building industry.
- **The substantial contracts of a school building programme can attract new secondary industries to the province and stimulate investment in existing business. The capital intensification of the local building products industry will bring local production techniques abreast of development in the rest of the country and abroad. The opportunity to export finished building components, or complete buildings rather than raw materials is seen as a further means to stimulate growth in local industry.**

- The inevitability of the industrialization of the building process has been recognized by the Federal government in its policies. The Department of Industry's BEAM programme is being acknowledged and adopted by other departments. C.M.H.C. and the Federal Department of Public Works have adopted the principles of modular co-ordination for their building programmes. The successful progress of the S.E.F. for the Metropolitan Toronto School Commission, and the R.A.S. Catholic School Commission programme in Montreal illustrate how other public clients are contributing to the controlled introduction of systems building.
- It is considered imperative to sponsor the concept in British Columbia at this point of development, before components of eastern system are imported, because of a lack of local initiative. The industrialized building system is essentially a regional concept. The benefits of improving construction methods throughout the province, promoting industrial growth and initiating the export of finished building components will not be achieved by importing products from elsewhere, even if it were economically feasible in some cases.



C.L.A.S.P. Mk. IV. System. Residential Colleges at York' University (England) under construction.

PART III. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS.

Question Three: What must be done in British Columbia to sponsor and sustain an industrialized building system for educational facilities?

PART III. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

QUESTION THREE: What must be done in British Columbia to sponsor and sustain an industrialized building system for educational facilities?

1. Definition of the market and its relationship to design characteristics of the building system

The choice of administrative methods made to organize the provincial school building programme will depend upon the volume and location of construction. In British Columbia the existing market can be divided into four distinct geographic areas.

Lower regional mainland...	15	school districts
Vancouver Island..........	14	" "
Okanagan Valley...........	10	" "
Prince George & vicinity...	2	" "

The practicability of treating the province as one market area is conditioned by the increasing transportation costs for delivery of components outside the lower mainland. Incidents of 2%-5% upon the "on site" unit cost of the heavier structural components are indicated. However, this figure need not represent a major deterrent when assessed against the overall saving that will be achieved with a larger market. The figures over the past eight years for the lower mainland indicate that the annual building programme is the minimum volume necessary to sustain a building system. However, experience elsewhere has shown that programmes in excess of $25 million are necessary in order for the manufacturers and fabricators to carry a substantial part of development costs.

The problem is essentially a choice between two alternatives:

One: Develop a building system to meet the particular "urban" requirements of the lower mainland. A high proportion of the development costs would be carried by the sponsor because individual contracts for components within the whole programme would not be large enough for manufacturers to justify extensive product development.

Two: Organize an annual or bi-annual volume of construction in excess of $25 million in order to transfer part of the development costs of a building system to the eventual participants, the manufacturers. A programme of this size can provide the client with more sophisticated buildings of better quality and greater variety, for less cost.

An analysis of the school construction programme for the lower mainland indicates that future requirements will be for a high proportion of 'Walk up' type buildings with an intermediate to high fire rating. Two factors contribute to this finding:

i) Enrolment forecasts indicate 44% increase in secondary pupils compared with 4% increase in elementary pupils 1966-67 to 1976-77. Analysis shows that virtually all secondary and from 50-60% of elementary school buildings in the lower mainland have been masonry construction over the period 1965-67.

ii) The sharp increase in land values over the past five years for the lower mainland must affect the site utilization by school buildings. Building codes require an equivalent fire rating to masonry construction for multi-storey buildings. Consequently, it can be argued that a building system developed exclusively for the lower mainland would have to meet the sophisticated requirements of multi-storey 'Walk up' type buildings. The development costs for such a building system are substantial, (the budget for research and development upon S. E. F. Metropolitan Toronto School Board has been $1.25 million to date, and the manufccturers are expected to carry a proportion of the actual design and development).

- This suggests that alternative one is impracticable with a one year programme, because of a high initial development cost offset against a limited market, showing a low potential overall return to the sponsor. A two year programme for the lower mainland would make it possible to organize a $25 million market and, consequently, justify the sponsorship of a system building programme. It is argued that a system developed exclusively for secondary school requirements in this area, which implies multi-storey fire resisting structure as a design type would represent a too inflexible response to school building requirements throughout the rest of the province.

The lower mainland represents the largest segment of the market followed by Vancouver Island. The requirements for multi-storey schools is greatest in the metropolitan areas and, consequently, the requirement for this type of building on the lower mainland can be supplemented by the requirements of other market areas. Population growth in the province from elsewhere is likely to boost the demand for elementary space in excess of the predictions, with new schools constructed in the fringe suburban areas.

It is therefore recommended that the best overall response to the provinces school building problem will be achieved by the sponsorship of a building system with the following two main characteristics.

- An open building system to ensure the two way benefits of interchangeability with eastern systems. It is likely that some specialized electric/electronic and mechanical eastern components will be used for a local system, and at the same time the export of components manufactured locally is a practical possibility.
- Secondly, a system with the design characteristics capable of meeting urban or suburban building requirements. The varied building code requirements (fire rating, etc.), could be solved economically by providing for the interchangeability of architectural components within the system, i.e. sub-systems, such as structure, internal partitions,

cladding, could be manufactured of the 'appropriate material' wood, steel or concrete, according to demand.

A system of this kind can be designated as an "open multi-characteristic building system". That is open to interchangeability with architectural components from outside the system, and open to interchangeability within the system itself to satisfy a 'range' rather than a 'set' of requirements.

It is pointed out elsewhere in this report that the variety of characteristics of a building system must have a realistic relationship to demand and that a larger volume of work can sustain a system with a greater variety of design features. Is is concluded that the best system building solution to the provincial school building programme is the approach recommended above, which will provide a means to solve immediate school building problems and which can be modified on the long term to satisfy changing market requirements.

It is further recommended that alternative two be adopted and implemented by the following means.

i)
- The school building requirements of the lower mainland be supplemented by addition of all similar school building requirements throughout the province.
- In areas where high transportation costs make systems methods marginally competitive with traditional building

system components can be used to advantage for certain elements of the building. Integration between traditional and systems methods of building construction can be achieved by the design of school building using the principles of modular co-ordination.

ii) The building programme can be supplemented by the addition of the following building types without compromising its effectiveness as a school building system.

a) Other educational uses can be met where space requirements are similar:

- Normal schools
- Technical institutes
- Junior colleges
- University space

b) Health centre and similar uses where the requirements for mechanical services are not specialized.

c) Small civic buildings, i.e., libraries, fire station, etc.

d) Office space commercial and civic.

- It is considered to be outside the terms of reference of this report to make recommendations concerning the legislative means of accomplishing the market organization, although it seems appropriate to comment upon the existing provincial methods and those means used elsewhere. It is evident that the present cost-sharing ratio of school financing does not encourage co-operate between school districts for any purpose, and by placing the entire responsibility for initiative of school building at the local level tends to emphasize the parochial interests of each school district. The successful operation of a building system within the limits of the provincial school building programme will require the antithesis of this approach. The effective use of school building resources depends upon a planned approach to the building programme administered with a consistent response to firm government policies.

- The Study of Educational Facilities for the Metropolitan Toronto School Board seeks to exploit and organize the existing market for school building that lies within the metropolitan Toronto administrative area. Individual member school boards contribute to and will enjoy benefits from this approach.
- The British methods of financing school building by establishing a fixed sum per pupil each year has had the effect of encouraging local counties to co-operate for mutual benefit because savings achieved by more effective methods of construction are used at the discretion of each district for special projects.

2. Sponsorship of the building system

- The question is, who will pay for the substantial research, design and development costs incurred in establishing an industrialized building system? Whose interests are great enough to justify the investment and carry the risk until the benefits become fact? There is a choice between commercial sponsorship, client sponsorship, or combinations of both where the eventual participants, the manufacturers carry part of the development costs.

I) Commercial sponsorship.

- The advantages to the client or purchaser of buildings are that the organizational problems and development costs are carried by the entrepreneur. The superficial advantages of system building will appear to have been provided, although development costs and profit will be included in the final unit price to the buyer.
- The entrepreneur will not invest capital in a building system unless there is a firm assurance of a construction programme large enough to sustain the system. In the case of school building where public money from various sources of revenue is being spent, it is not in the public interest to give one company exclusive access to the captive market of the building programme. The combines act also legislates against this kind of eventuality. Experience in Europe and Britain indicates that the desire to compete for this market will cause the sponsorship of other commercial systems of a similar type. This trend has led to a proliferation of systems which cancels out the immediate economic advantages to the client and the long term benefits to the community. In Britain, there are over three hundred "closed"

building systems, (i. e., the components of one system are not interchangeable with any other); only forty of them are economically viable. The others are either used to construct a few buildings each year or are utilized as devices to get work by large contracting organizations and package dealers. The long term economic effect of the proliferation of commercial systems in British Columbia is seen as particularly undesirable because of the limited size and regional nature of the school building programme.

- Commercial sponsorship does not provide the client with one of the fundamental advantages of system building, that of the opportunity to monitor and control the process of building in such a way that the improvements in productivity accrue to the client. The reality of commercially sponsored systems is that costs will be kept competitive enough to ensure an adequate volume from part of the market, on the other hand it is likely that real cost savings from improved productivity will go to the entrepreneur who invested in the system.
- The commercially sponsored school building system has another fundamental limitation. The factor of repetition in factory production, which reduces unit prices for the consumer will provide increasing profit to the manufacturer only so long as there are no major design changes. This means that there is no built-in incentive or opportunity for feedback for a commercial sponsor to modify his design to adapt to new curriculum patterns, or to meet the more sophisticated

requirements of an expanding market.

The sponsors organization will have a direct relationship to members of the building industry, but only a tangential contact with future clients. Experience with commercial systems elsewhere indicates that because the client has no opportunity for initial participation to determine his requirements he is presented with a "carte blanche" choice after development has occurred.

- It was found that the method of commercial sponsorship is unsatisfactory for the reasons outlined, and that this method of sponsorship fails to meet the conditions set forth in Part I items 2, 4, and 6 of this report.

II) Client Sponsorship.

- The client-owner is in a much stronger position to sponsor an industrialized building system, and various methods can be used to offset part of the total cost of research, design and development.
- The evolutionary approach was pioneered in Britain and is appropriate to their particular combination of local responsibilities and administrative methods. The high initial cost was kept to a minimum by the use of staff educators and architects. The manufacturers were willing to participate on component development because of a preferred opportunity for future work. As the building consortiums grew, research and development groups of professionals were set up to refine the entire process. This was financed by 1/4% levy upon the total building programme. This approach has proven to be very

successful for English conditions where a high proportion of the school work is done by staff architects employed by local authorities. Two public building consortiums C. L. A. S. P. and S. E. A. C. have current building programmes in excess of $55 million annually. However, this method is not considered to be directly transferable to meet local conditions.

- The phased approach has, and is currently being used by three major school building programmes sponsoring system building methods, S. C. S. D. in California, R. A. S. for the Catholic School Commission in Montreal, and S. E. F. for the Metropolitan Toronto School Board. A division of professional responsibilities is made between determining and formalizing the client's needs and the actual design and development with industry and is undertaken in the following way:

Phase I.

- An autonomous organization is set up outside the existing educational administrative structure. Its purpose is to undertake an "in depth" study of the client's educational building requirements and to formalize the findings in such a way that the programme can be bid on by groups in the building industry. The organization consists of staff members and consultant educators and architects who possess the specialized knowledge of the systems approach. The technique of "performance specifications" derived from the aero-space industry have been used to formalize the client's environmental building requirements without prejudicing the ultimate outcome by specifying particular materials or products. The bid procedures are set up in such a way that a unit price is determined for the complete environmental system.

Phase II.

- A building programme in excess of 1-$^1/2$ million square feet is put out to bid to industry by the client's organization. If the market conditions have been assessed correctly groups of manufacturers will be prepared to bid a building system on the basis of the opportunity of being awarded the contract. The manufacturers group will have to be prepared to carry the costs of the design consultant's fees, plus their own development costs for component design. If the programme is large enough, this approach can generate the sponsorship of building systems by commercial interests, and also create a situation where sub-systems (i.e., mechanical equipment, lighting systems), are designed specifically for the school market. The penalties of causing a proliferation of "closed building systems" (described under commercial sponsorship) can be overcome in the bidding procedures by requiring "face-to-face" compatibility of components (i.e., sub-systems) outside their own sponsorship group. If this is achieved, the client will then enjoy the opportunity of nominating the most competitive sub-system bid from each of the sponsoring groups. This approach creates an opportunity for the design professions to participate in the design and development of components that they will eventually use in the design of individual schools. The comments on present conditions in the province noted that very little effective liaison presently exists between the design professions and the manufacturing industry.

Phase III.

- The unit price for the successful building system and for individual components is determined upon the basis of a bulk order for a year's building programme. Each school district will engage professional consultants in the traditional manner to determine local educational requirements. However, all the predictable benefits of system building cost, quality and time control are provided for participating school districts.
- Variety of design and appearance is not an obstacle. If the local architect is dissatisfied with the choice of outside appearance available with the system on aesthetic grounds, custom facades or features using traditional building can be added on a non-shareable cost basis.
- The successful bidders in this approach will tend to improve their methods and stay competitive from year to year. New manufacturers groups may form to sponsor and bid their own building system. This evolutionary process is regarded as healthy only so long as the systems bid are "open", that is, each sub-system had face-to-face compatibility with existing products. The bidding procedures are devised to satisfy the immediate requirements of a building system, and to speed up the industrialization of the building industry, without stifling the principle of free enterprise.

It was found that the phased approach is the appropriate method of sponsorship for an educational building system for British Columbia. The approach satisfies the conditions set out in part I of this report, and is considered to be an intrinsically flexible method of harnessing professional services and local manufacturing potential to existing institutions and administrative organizations.

The initial phase provides an opportunity for the needs of vested interests to be expressed by consultation without the problem of confrontation or change within existing organizations.

The second phase provides an opportunity for the design professions to contribute their ideas in a new and creative way, and places the "status quo" advocates in a questionable position.

- The third phase can occur within the existing structure of local school districts and offers the benefits of cost, quality and time control, plus freedom of design.
- Total costs of design and development are carried jointly by the client and the building industry. The client's major cost is incurred in the analysis of requirements and the preparation of specifications so that the school construction programme can be bid upon by industry. The cost of design and development of the building system is carried by interested groups of manufacturers if the client's requirements are appropriate to the size of the programme being bid. The cost of on-going management, research and development can be carried by an annual levy on the total programme.

It is recommended that the provincial government and the school trustees establish a provincial SCHOOL BUILDING CONSORTIUM as a fiscal and legal body to implement the phased approach to sponsorship of an industrialized building system, as set out in this report.

It is further recommended that the preparation of the client's requirements in terms of legal documents for public tender be undertaken by a RESEARCH, DESIGN AND DEVELOPMENT GROUP established as an autonomous organization outside existing educational institutions directly responsible to the provincial SCHOOL BUILDING CONSORTIUM.

3. The rationalization of educational requirements

The need to rationalize educational activities and requirements for school building exists because the design of the building system establishes qualities and performance characteristics for that system. In turn, these "features" will modify the kind of variety that the local architect can incorporate in schools.

The formalization of the design programme with educational specifications (which has traditionally been determined at a personal level in local school districts) is necessary because of the comprehensive nature of solutions offered by systems building. The commitment to this approach once made is a substantial one and consequently a thorough analysis must be undertaken to ensure all essential educational issues have been considered.

The educational specifications.

The interpretation of educational specifications by the designer is not a linear process, because a number of other prime considerations will have to be met at the same time. It is therefore important that four aspects of the problem be defined in the specifications:

i) The educational theory. The thinking behind the general approach should be defined in ideal terms, together with any commitment to long term goals.

ii) Administrative context. The provincial educational and fiscal policies will require reviewing because they act as a filter for the theory.

iii) Curriculum patterns. The activities within the school and the immediate considerations that determine them, teaching methods, group sizes, audio-visual media and so forth require formal definition in order that they can be used as design factors by the designer.

iv) Comment upon interpretation. The designer will interpret the specifications not translate them, so that a basis for choice between priorities must ideally be established by the educator. An understanding of mutual interests must exist before the specifications can become useful documents for design.

It is recommended that the analysis of educational requirements and preparation of educational specifications occurs in phase one of the process and be undertaken by staff educators and architects of the RESEARCH, DESIGN AND DEVELOPMENT GROUP in consultation with others.

4. The role of the professional designer

- The introduction of systems building methods as a means of speeding the process of industrialization in the building industry establishes far broader terms of reference for problem solving than exist at the moment with the traditional building by building method.
- The means of accomplishing a comprehensive approach depends upon the application of specialized professional knowledge within new relationships in the building industry. It is a new game with different ground rules. Please refer to the comments in Part II, paragraph 4, regarding the future of industrialized building.
- The tasks to be undertaken exist at various levels within the industry. The problem for the client sponsor is how to put existing expert knowledge to the most effective use? Secondly, how to create a situation where the professional engaged in a normal business practice can make a useful contribution?

It is recommended that the most effective use of professional services will be achieved by redeploying talent set within new operating relationships in the building industry.

The phased method of sponsoring systems building put forward in Part II, paragraph 2, establishes a differentiation of tasks and responsibilities for the professional designer and consultants within a new framework of decision making. The bar chart in Appendix II illustrates how the new tasks interlock with existing procedures.

Phase I. The client's research and design group.

The task of analysing the educational requirements and preparing environmental performance specifications is a challenging problem. One best accomplished by an inter-disciplinary group of professionals. There is no recognized overlap between the educational problem and design solutions so that formalization of requirements for such a broad range of needs must be undertaken by professionals, educators, and architects, who are prepared to overcome the communications gap by understanding the others' problems and points of view.

Phase II. Design and development of the building system by manufacturers' sponsored groups.

The client's specifications are prepared in order to encourage competent groups of manufacturers to bid the problem of designing, developing, and supplying the components of a building system. The initiative for industry to form consortiums must be supplemented by effective public relations from the client's R.D. & D. group.

The role of the professional designer, architect and engineer, for this phase is to prepare a design for the system that meets the client's specifications and manufacturer's capabilities. A new problem situation has been created where the professional designer must work in liaison with the manufacturer to satisfy the design features of the performance specifications and the factors that effect optimum factory production.

Phase III. The design and construction of the school for the local school district.

It will be appreciated that Phase III encompasses the present traditional role of the professional architect with the difference that building components will be ordered from the "system catalogue" rather than from the normal trade catalogue. The predetermined dimensions and assured cost of systems building components will reduce drawing office time and leave the architect free to spend more time upon his client's detailed educational requirements. The architect will be able to provide the local district with school buildings of assured cost, quality and completed on time because of the back-up organization provided by the client's RESEARCH, DESIGN AND DEVELOPMENT GROUP.

5. The re-bidding of the school component building programme on an annual or bi-annual basis

- The cycle of demand for school space lends itself admirably to organization into an annual construction programme. There are two reasons for bidding school building programmes on an annual or bi-annual basis.

Sub-system tenders related to actual costs

i) It is in the client's short and long term interests to ensure that the manufacturer's unit prices are related to actual costs. Over-commitment by a major supplier on the basis of ignorance will lead to difficulties for all participants of the programme, not just that company that stands to lose money. Experience elsewhere indicates that the actual benefits of system building (economic and others) will not be completely evident until the method has been in operation for at least three programmes. The first programme's bids are likely to vary from the conservative (high) to the uninitiated (low) because of the unknowns in the situation. The second programme's bid may reflect over-optimism (very low) on the part of competition in order to beat out the original successful bidders. The third programme's bids are most likely to reflect a more stable attitude to what is possible, because the manufacturers will be bidding upon known costs and experience.

Organization of plant production for peak productivity

ii) Re-bidding the programme every year will attract the participation of major manufacturers because a substantial contract scheduled on a building by building basis provides the opportunity to organize plant production for peack productivity. The introduction of new products to compete for a systems building programme is regarded as both healthy and desirable since the progressive effect of this trend will be to stimulate the industry to re-group its operations in a more effective manner. The evolutionary approach to increasing productivity must be supplemented by policies which expose the participating companies to the realities of competition.

It is recommended that the requirements for the provincial SCHOOL BUILDING CONSORTIUM, as set out in Part III paragraph 2 of this report, be organized into bi-annual programmes to be bid upon by individual manufacturers on the basis of an integrated building system.

6. On-site specialization and sub-system bidding procedures

- It is important to ensure that improved methods occur throughout the building industry and are not limited to one aspect of the whole operation. The rationalization of site assembly procedures for the erection of buildings is an innovation that has been pioneered by systems methods. This is desirable because of the repetition of similar assembly operations and is possible because repetition justifies the allocation of design time to the problem. The opportunity for the standardization of detail and consideration of assembly procedures as a design problem does not exist in traditional construction methods. Mistakes and unnecessary duplication of work due to unfamiliarity with details unique to one building can be eliminated by training personnel for the repetition of systems building. The planned approach allows the general and sub-systems contractor to train and retain assembly crews over a sustained period of time, which will pay off in increased profits to the contractor and reduced unit prices to the client.

The sub-contractors for an individual building normally stay together for one job, whereas the system building contracts provide for a sustained relationship between the general contractor and/or sub-contractors. The sub-contractor who "supplies and installs" one type of component for all contracts, (i.e., a manufacturer), will have sustained contact with a number of general contractors. In both cases, a new opportunity for feedback has been established which will provide a better understanding of mutual problems than exists at the moment.

- In view of these considerations it is necessary to ensure on site specialization will in fact occur. The means adopted essentially depends upon the method of bidding used for the entire systems programme. If the sub-system tenders are to supply the components only, means must be devised to ensure that specialization occurs with the general contractors on site assembly crews. Serialized contracts for a number of schools awarded to a general contractor by local school districts will have the effect of encouraging the training of specialized personnel.
- Where the sub-system contracts are to supply and install particular

components or to fulfill particular system tasks the opportunity for specialization of assembly crews is intrinsic to the method of bidding. In this case there is a much greater possibility that the new resource of trained personnel will continue to be available to participate in future systems programmes, whereas the potential of the trained crews at the general contractors level could easily be lost if the contractor undertakes other kinds of projects.

It is therefore recommended that the specialization of on site assembly operations be encouraged by sub-system building contracts which require the design, development, supply and installation of building components as a package or fulfillment of specific tasks as a package by one or a group of companies.

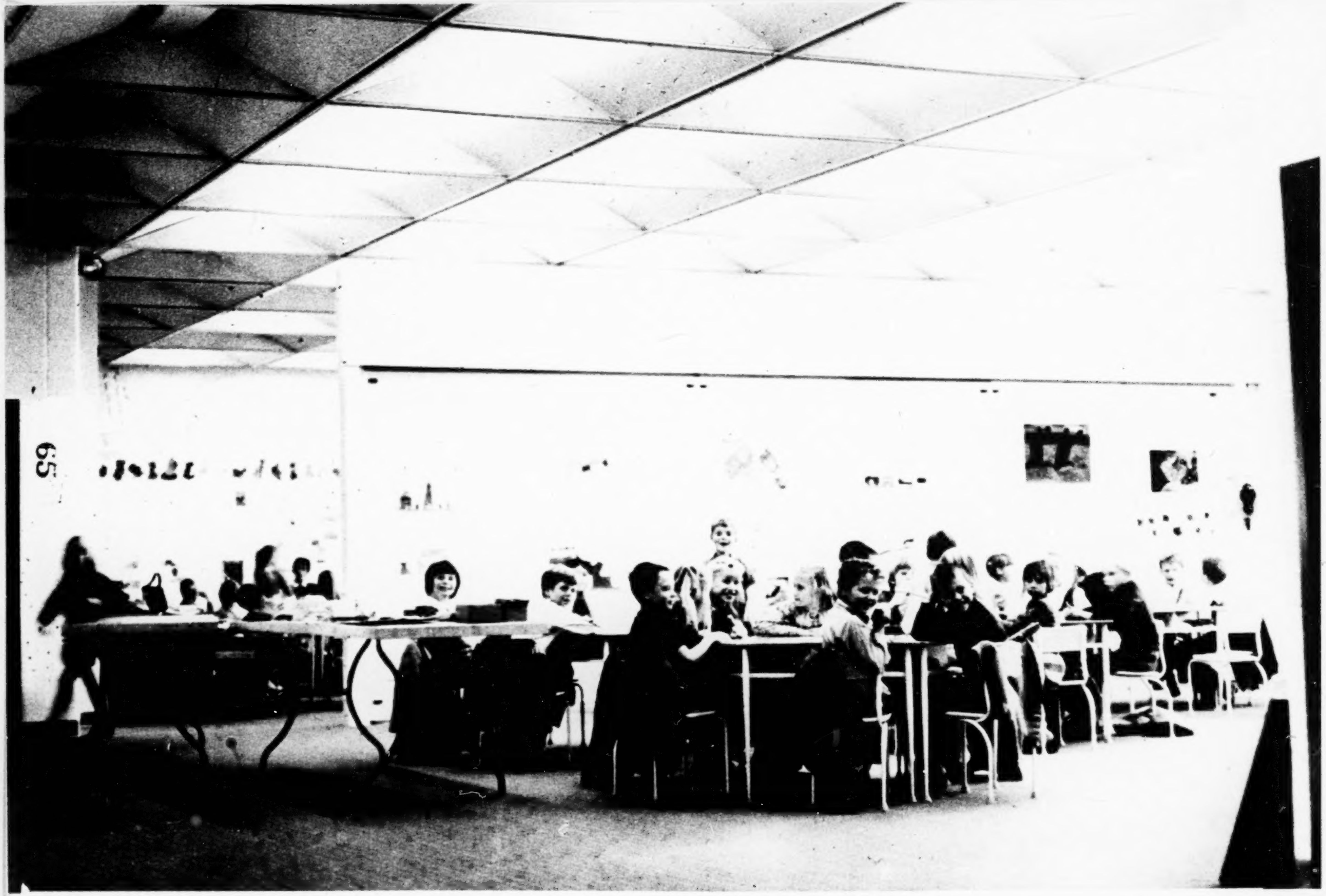
7. Organization for on-going management, administration, research and development

a) Administration.

The client (provincial government and the school trustees) will be faced with the problem of co-ordinating school construction programmes of the participating school districts in order to organize the market for systems building. Once the annual programme has been established, it is necessary to determine the quantity and type of building components that comprise the programme to be bid. Each participating school district must prepare preliminary designs for schools in its current programme, using architectural planning principle determined by the building system. The manufacturer will then be able to tender firm prices for the system based upon pre-determined quantities. Contingencies can be allowed for by quoting unit prices reduced by percentage increments for an increased annual volume. Administration of this process will be required upon a continuous basis as each programme is bid.

b) The relationship of Research and Development to management. The case for continuous research and development is put forward in Part I - section 6 of this report. After the first building programme has commenced the client will require a means to monitor and control the total building process in order to assure that the day to day procedures are in fact contributing to the long term goals of the programme. The effectiveness of the whole range of operations that occur within the building programme; i. e. on site assembly operations, production methods, design procedures and management must be continually subject to reassessment. An organizational undertaking of this scale will require the information provided by continuous research and development in order to ensure the approach is effective. The basis for management's thinking for improvements in operating policies will be provided by the information and ideas provided by an interdisciplinary professional team, the Research, and Development group.

It is recommended that the combined tasks of on-going management administration, research, design and development essential for the operation of the provincial SCHOOL BUILDING CONSORTIUM, be undertaken by the client's RESEARCH DESIGN AND DEVELOPMENT GROUP as the administrative control organization.



S.E.F. system. Open classroom area at the Eastview School addition, Toronto.

APPENDICES.

I Estimate of capital cost and cost saving.
II Diagram of phased approach.
III Volume of provincial school construction 1960 - 67.
IV Analysis of types of construction 1960 - 67.
V Comment on STUDY OF EDUCATIONAL FACILITIES progress to date.
VI Bibliography.

APPENDIX - ITEM I

Estimate of capital cost and cost savings

1. Estimate of capital costs incurred in development

The phased approach to sponsorship is a means to ensure that the major participants and benefactors of the systems approach carry an appropriate proportion of the development costs. The client-owner's share of the capital investment will be incurred from the cost of sustaining the RESEARCH, DESIGN AND DEVELOPMENT GROUP for a minimum period of two years. The phased approach will ensure that the technical development costs will be carried by industry as part of the bidding procedures. Once the SCHOOL BUILDING CONSORTIUM is established as a going concern, the R.D.D. group's annual budget can be financed by a 1/3% levy on the total building programme.

- Capital cost incurred by the client-owner sponsor for financing the RESEARCH, DESIGN AND DEVELOPMENT GROUP for a period of two years.

Salaries.

Two principal staff members (one educator and one architect) at an annual salary of $20,000	$ 40,000.00
Tenstaff members (technical and administrative) at an annual average salary of $10,000.00	100,000.00
Total for one year	$140,000.00

Total for two years.............	$ 280,000.00
Other costs: Rent for office space, materials, printing, etc.	80,000.00
Consultants fees: Outside consultants fees for educational, design and engineering.	120,000.00
Total capital costs incurred by client-owner	$ 480,000.00

2. Estimate of capital savings available to individual school districts with full membership of the provincial SCHOOL BUILDING CONSORTIUM.

The individual school district can achieve major savings on capital costs for school construction by participating as a full member of the provincial SCHOOL BUILDING CONSORTIUM. Each member will contribute its own local building programme to the bulk programme of the consortium and will benefit from the reduction of construction costs by the systems approach. The estimate of cost in part 2, section 2, for the structural assemblies of a 30,000 sq. ft. school purchased individually and thirty at a time indicates a potential saving of 28% over traditional building methods. The economies of scale applied to other building components indicate less or an equal percentage (i.e., 20% - 25%) of savings. The capital cost of development, plus the annual cost of administration must be offset against these potential savings.

Precedent in Britain and U. S. A. indicate an overall reduction of capital construction costs of the following order:

- CONSORTIUM OF LOCAL AUTHORITIES SPECIAL PROGRAMME

Nottingham, England (current annual programme $55 million)
savings over traditional methods........ 15%

- SOUTH EASTERN ARCHITECTS COLLABORATIVE.

Hartford, England (current annual programme $54 million)
savings over traditional methods........ 8%

SCHOOL CONSTRUCTION SYSTEM DEVELOPMENT.

Southern California. 1966 building programme $26 million.
savings over traditional methods
on components bid (approximately
half of total school cost)............... 18%

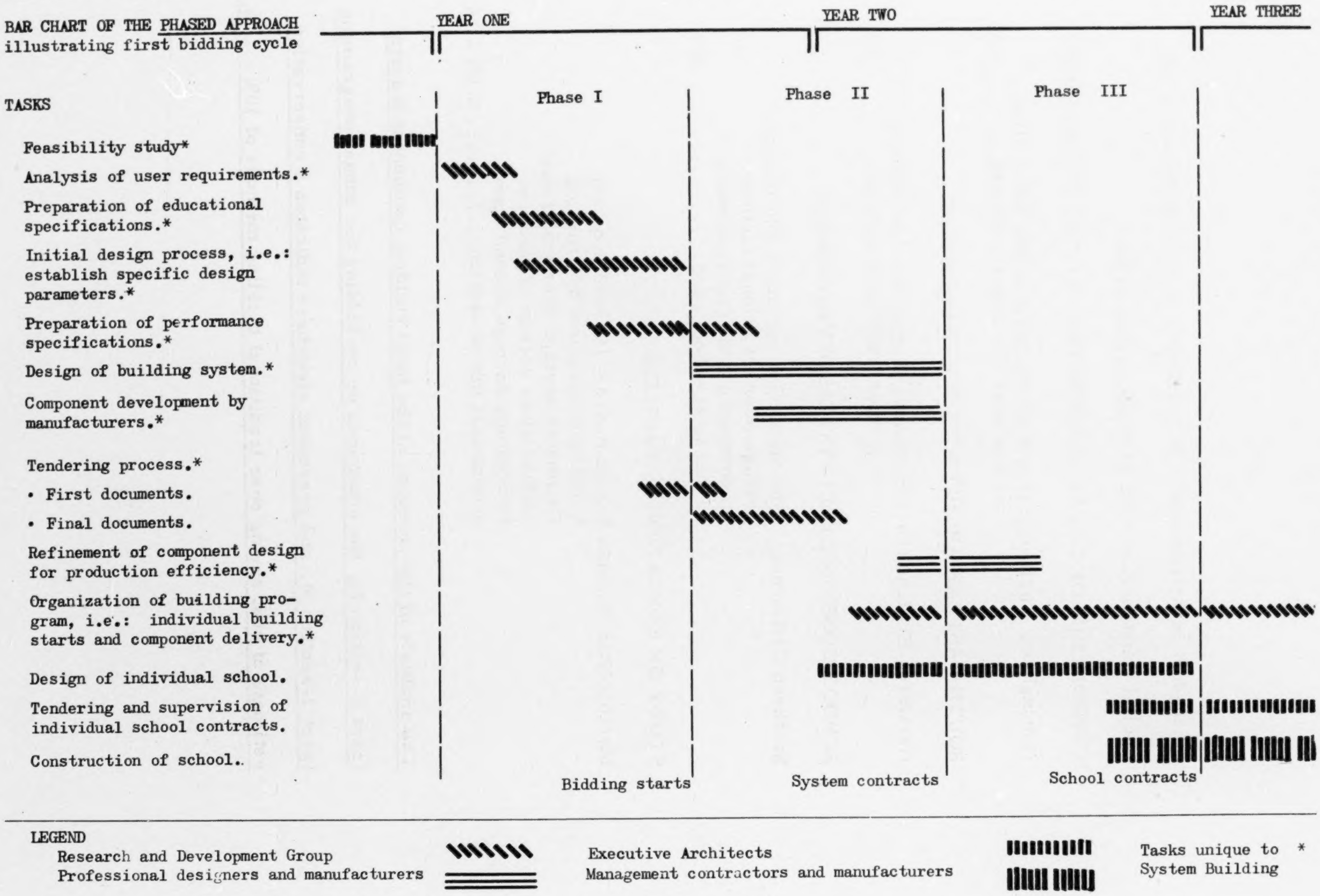
- STUDY OF EDUCATIONAL FACILITIES.

Metropolitan Toronto School Board. 1969-70 two year
building programme $39 million.
Estimated savings over traditional
method after receipt of tenders.
Percentage savings depend upon
economical use of system........... 8.5% - 14.24%

The analysis of the potential of the local building component industry (part 2-section 2), the comments on re-bidding the annual programme (part 3-section 5), and precedent elsewhere indicates a conservative estimate of cost saving over traditional building methods of 10% - 12%.

APPENDIX - ITEM II

BAR CHART OF THE PHASED APPROACH
illustrating first bidding cycle



APPENDIX - ITEM III

Volume of provincial school construction 1960-67, classified by cost, square feet and geographic location.

1960	Total area (sq. ft.)		Total cost
Lower mainland	677, 759		$ 6, 558, 989. 00
Vancouver Island	20, 587		193, 698. 00
Okanagan			1, 492, 613. 00
Prince George			405, 785. 00
Other districts			1, 622, 860. 00
		Total	$ 10, 273, 945. 00
1961			
Lower mainland	303, 817		$ 3, 016, 931. 00
Vancouver Island	120, 539		1, 071, 056. 00
Okanagan			542, 303. 00
Prince George			583, 964. 00
Other districts			12, 457, 162. 00
		Total	$ 17, 671, 416. 00
1962			
Lower mainland	356, 083		$ 3, 540, 345. 00
Vancouver Island	174, 650		1, 793, 515. 00
Okanagan			730, 853. 00
Prince George			195, 500. 00
Other districts			9, 347, 440. 00
		Total	$ 15, 607, 653. 00
1963			
Lower mainland	636, 326		$ 7, 262, 453. 00
Vancouver Island	130, 070		1, 413, 339. 00
Okanagan			417, 917. 00
Prince George			522, 235. 00
Other districts			7, 144, 325. 00
		Total	$ 16, 760, 269. 00

1964	Total area (sq. ft.)		Total cost
Lower mainland	684, 235		$ 8, 940, 355. 00
Vancouver Island	193, 450		2, 336, 251. 00
Okanagan			1, 272, 694. 00
Prince George			1, 019, 038. 00
Other districts			6, 905, 327. 00
		Total	$ 20, 473, 665. 00
1965			
Lower mainland	748, 943		$ 10, 260, 325. 00
Vancouver Island	336, 946		4, 482, 340. 00
Okanagan	198, 319		2, 699, 281. 00
Prince George	41, 440		559, 788. 00
Other districts			17, 963, 137. 00
		Total	$ 35, 964, 871. 00
1966			
Lower mainland	577, 099		$ 9, 310, 405. 00
Vancouver Island	454, 789		7, 849, 239. 00
Okanagan	262, 524		3, 513, 436. 00
Prince George	311, 976		5, 203, 504. 00
Other districts			17, 240, 414. 00
		Total	$ 43, 116, 998. 00
1967			
Lower mainland	1, 037, 273		$ 17, 568, 476. 00
Vancouver Island	626, 636		11, 132, 494. 00
Okanagan	348, 533		5, 599, 422. 00
Prince George	185, 755		4, 106, 430. 00
Other districts			6, 320, 877. 00
		Total	$ 44, 727, 699. 00

Note. The total areas and capital costs for the four designated geographic areas were derived from the existing building records in the Department of Education, Victoria; whereas the totals for each year are a record of the actual capital spent. It was not possible to establish a factor of error due to incomplete records, so that the totals for the Lower Mainland, Vancouver Island, Okanagan, and Prince George may be 10% - 15% less than actual final capital costs. The total for 'Other districts' was arrived at by substracting the grand total of the other four areas from the amount actually spent and is consequently only a composite total.

- Each geographic area includes the following school districts:

Lower mainland:	School districts:	32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, and 48.
Vancouver Island:		61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 84, 85.
Okanagan:		14, 15, 16, 17, 18, 19, 21, 22, 23, 24.
Prince George:		56, 57.
Other districts:		All other districts in the province not noted above.

APPENDIX - ITEM IV

Analysis of types of construction 1960-67, classified by building code categories and georgraphic areas, expressed as a percentage of each year's construction volume.

Lower Mainland Districts
1960 - 1967

ELEMENTARY				SECONDARY			
Yr. 1960	Frame	Composite	Masonry	Yr. 1960	Frame	Composite	Masonry
1 floor	19.5	10.7	0.9	1 floor	0.7		
2 floors	0.7	3.7	6.6	2 floors		14.7	32.9
3 floors +				3 floors +			9.6
Total %	20.2	14.4	7.5	Total %	0.7	14.7	42.5

Yr. 1961	Frame	Composite	Masonry	Yr. 1961	Frame	Composite	Masonry
1 floor	28.7	23.5	6.2	1 floor	3.7	2.1	
2 floors	0.7	22.4	6.4	2 floors	1.9		4.9
3 floors +				3 floors +			
Total %	29.4	45.9	12.6	Total %	5.6	2.1	4.9

Yr. 1962	Frame	Composite	Masonry	Yr. 1962	Frame	Composite	Masonry
1 floor	50.3	18.5	4.0	1 floor			
2 floors	11.2	7.8	1.9	2 floors			1.0
3 floors +			5.3	3 floors +			
Total %	61.5	26.3	11.2	Total %			1.0

Yr. 1963	Frame	Com-posite	Ma-sonry
1 floor	29.8	23.1	20.6
2 floors	6.0	9.8	8.6
3 floors +			
Total %	35.8	32.9	29.2

Yr. 1963	Frame	Com-posite	Ma-sonry
1 floor	0.1		0.8
2 floors		1.2	
3 floors +			
Total %	0.1	1.2	0.8

Yr. 1964	Frame	Com-posite	Ma-sonry
1 floor	24.5	19.9	5.0
2 floors	7.8	14.3	8.8
3 floors +			2.9
Total %	32.3	34.2	16.7

Yr. 1964	Frame	Com-posite	Ma-sonry
1 floor			0.4
2 floors			16.4
3 floors			–
Total %			16.8

Yr. 1965	Frame	Com-posite	Ma-sonry
1 floor	33.3	28.0	5.0
2 floors	7.2	10.5	
3 floors +			
Total %	40.5	38.5	5.0

Yr. 1965	Frame	Com-posite	Ma-sonry
1 floor	0.3	0.3	1.8
2 floors		2.5	11.1
3 floors +			
Total %	0.3	2.8	12.9

Yr. 1966	Frame	Com-posite	Ma-sonry
1 floor	24.2	28.5	0.6
2 floors		12.7	0.4
3 floors +			
Total %	24.2	41.2	1.0

Yr. 1966	Frame	Com-posite	Ma-sonry
1 floor	1.9	8.3	
2 floors		9.6	10.8
3 floors +		3.0	
Total %	1.9	20.9	10.8

Yr. 1967	Frame	Com-posite	Ma-sonry	Yr. 1967	Frame	Com-posite	Ma-sonry
1 floor	18.9	32.6	3.9	1 floor		8.9	2.9
2 floors	1.5	6.0	3.8	2 floors		5.4	8.9
3 floors +				3 floors +			7.2
Total %	20.4	38.6	7.7	Total %		14.3	19.0

Vancouver Island Districts
1960 - 1967

ELEMENTARY				SECONDARY			
Yr. 1960	Frame	Com-posite	Ma-sonry	Yr. 1960	Frame	Com-posite	Ma-sonry
1 floor	66.9			1 floor	33.1		
2 floors				2 floors			
3 floors +				3 floors +			
Total %	66.9			Total %	33.1		

Yr. 1961	Frame	Com-posite	Ma-sonry	Yr. 1961	Frame	Com-posite	Ma-sonry
1 floor	44.4	3.3		1 floor			
2 floors	3.2			2 floors		49.1	
3 floors +				3 floors +			
Total %	47.6	3.3		Total %		49.1	

Yr. 1962	Frame	Com-posite	Ma-sonry	Yr. 1962	Frame	Com-posite	Ma-sonry
1 floor	49.5	1.5		1 floor	12.6		
2 floors	4.8		28.3	2 floors	3.3		
3 floors +				3 floors +			
Total %	54.3	1.5	28.3	Total %	15.9		

Yr. 1963	Frame	Composite	Masonry
1 floor	34.5	20.7	
2 floors	1.4		35.0
3 floors +			
Total %	35.9	20.7	35.0

Yr. 1963	Frame	Composite	Masonry
1 floor			
2 floors	1.6		6.8
3 floors +			
Total %	1.6		6.8

Yr. 1964	Frame	Composite	Masonry
1 floor	61.2	3.1	1.6
2 floors	3.8	4.5	
3 floors +			
Total %	65.0	7.6	1.6

Yr. 1964	Frame	Composite	Masonry
1 floor	22.2		
2 floors	3.6		
3 floors +			
Total %	25.8		

Yr. 1965	Frame	Composite	Masonry
1 floor	43.4	21.8	
2 floors	3.4	3.1	6.9
3 floors +			0.3
Total %	46.8	24.9	7.2

Yr. 1965	Frame	Composite	Masonry
1 floor		9.4	
2 floors	1.9	9.8	
3 floors +			
Total %	1.9	19.2	

Yr. 1966	Frame	Composite	Masonry
1 floor	14.1	21.9	0.7
2 floors	10.0	11.9	
3 floors +			
Total %	24.1	33.8	0.7

Yr. 1966	Frame	Composite	Masonry
1 floor		36.7	
2 floors	2.3	2.4	
3 floors +			
Total %	2.3	39.1	

Yr. 1967	Frame	Com-posite	Ma-sonry	Yr. 1967	Frame	Com-posite	Ma-sonry
1 floor	18.9	30.2	2.3	1 floor	0.5	10.8	
2 floors		18.9	7.5	2 floors			10.9
3 floors +				3 floors +			
Total %	18.9	49.1	9.8	Total %	0.5	10.8	10.9

Okanagan Districts 1965 - 1967

ELEMENTARY				SECONDARY			
Yr. 1965	Frame	Com-posite	Ma-sonry	Yr. 1965	Frame	Com-posite	Ma-sonry
1 floor	22.2	41.2		1 floor	0.8	18.5	
2 floors		6.8		2 floors		10.5	
3 floors +				3 floors +			
Total %	22.2	48.0		Total %	0.8	29.0	

Yr. 1966	Frame	Com-posite	Ma-sonry	Yr. 1966	Frame	Com-posite	Ma-sonry
1 floor	20.1	57.3		1 floor	6.3	2.1	
2 floors		5.5		2 floors		8.7	
3 floors +				3 floors +			
Total %	20.1	62.8		Total %	6.3	10.8	

Yr. 1967	Frame	Com-posite	Ma-sonry	Yr. 1967	Frame	Com-posite	Ma-sonry
1 floor	7.8	11.4		1 floor		3.1	
2 floors		8.7		2 floors		25.5	43.5
3 floors +				3 floors +			
Total %	7.8	20.1		Total %		28.6	43.5

Prince George Districts 1965 - 1967

ELEMENTARY				SECONDARY			
Yr. 1965	Frame	Composite	Masonry	Yr. 1965	Frame	Composite	Masonry
1 floor	6.6	93.4		1 floor			
2 floors				2 floors			
3 floors +				3 floors +			
Total %	6.6	93.4		Total %			

Yr. 1966	Frame	Composite	Masonry	Yr. 1966	Frame	Composite	Masonry
1 floor	1.3	24.7		1 floor		74.0	
2 floors				2 floors			
3 floors +				3 floors +			
Total %	1.3	24.7		Total %		74.0	

Yr. 1967	Frame	Composite	Masonry	Yr. 1967	Frame	Composite	Masonry
1 floor		74.5		1 floor			
2 floors		25.5		2 floors			
3 floors +				3 floors +			
Total %		100.0		Total %			

APPENDIX - ITEM V

Comments on the Metropolitan Toronto School Board STUDY OF EDUCATIONAL FACILITIES progress to date, with reference to the implications for a system building programme in British Columbia.

The success of the S.E.F. programme represents in many ways a significant breakthrough in design and construction methods for the Canadian building industry. The approach to greater industrialization is being accomplished by offering a building programme with incentives to induce reorganization within the existing resources of industry rather than leapfrogging what exists with entirely new methods and capital investment. The effectiveness of the programme has depended upon the willingness of many individual companies to participate by developing products for the school market administered by Metro Toronto. New relationships between client, professional and members of the industry have been established which will ensure improvement in the construction process and greater productivity in the long run.

The significance of the S.E.F. programme is that for the first time in Canada or North America, a truly "open" building system has been established using competitive bidding procedures whilst ensuring a great variety of choice to the client. One of the many pitfalls in system building is that if the design of the system is tackled in the same manner as the design of the individual building by one architect, the outcome, a closed system can become a real roadblock to improvement, and change later on. The notion of dull monotonous repetition may very well become a reality if the sponsor/client is lock-stepped into a closed building system. Whereas the open system is capable of improvement and change both of quality and design, and can generate a variety of alternatives appropriate to particular requirements of the time.

The Study of Educational Facilities for Metropolitan Toronto represents an in depth analysis of the related problems of education, building and management with a resolution of problems expressed in terms of an on-going process "systems building". The change of approach from a fragmented to a comprehensive process has allowed S. E. F. to develop new building techniques and management methods which will allow Metropolitan Toronto to handle its educational building problem in a more effective and economic manner.

It has been assumed that the reader has some general knowledge of the process adopted by the S. E. F. programme so that these following comments are focused on the significant achievements and experience as related to the implementation of a systems building programme in British Columbia.

i) Research and development completed to date.

- The areas of research and development undertaken by the S. E. F. staff group and the participating members of the building industry in Ontario represents a major resource of Canadian experience with system building. The question is how can a system building programme for British Columbia tangibly benefit from the progress of the S. E. F. programme?

- S. E. F. research programme.

The analysis of Metropolitan Toronto's educational requirements and the subsequent translation into architectural performance specifications is fully documented and available as resource material. The S. E. F. programme represents a major step in coordinating and upgrading the educational and architectural building standards for new schools in Metropolitan Toronto which now, as a result, are considerably higher than other suburban and rural Ontario areas. It cannot be assumed that these standards are directly applicable to British Columbia problems and consequently an assessment of the relevance of the educational goals and cost/quality features of the S. E. F. system must be undertaken as a preliminary to the sponsorship of a system building programme locally.

- Development work by manufacturers.

One of the major effects of the S.E.F. programme has been to induce the building industry to invest an estimated $2-1/2 million (S.E.F. staff estimate) on the development of products designed specifically for the educational building market in Eastern Canada. The ten successful bidders will naturally continue with their own development work to complete their contract commitments, whereas there are over twenty companies whose investment to meet the S.E.F. performance specifications will find no direct outlet with the S.E.F. programme. A probable outcome of this situation is that individual and consortiums of companies will complete development on these new products and proceed to seek out markets for themselves. This trend is a natural outcome of the open systems approach and as mentioned elsewhere can be regarded as desirable so long as these new products are interchangeable with other system components.

However it should be appreciated that the simple expedient of introducing one or two sub-systems into a new building will not provide the cost/quality improvements of a system building programme to the client. It must be born in mind that one of the major factors to the manufacturer in determining a unit price for a guaranteed quantity is that his component must possess face-to-face compatibility with other system products. A condition that has been achieved by extensive liaison with other nominated companies, consequently if the component is used with unknown products or unresolved traditional building details the unit price is bound to be higher regardless of any benefits of a guaranteed market.

It is concluded that a system building programme for British Columbia would benefit greatly if the bidding methods encouraged participation from companies already experienced in the systems approach. Further study is necessary to determine the kind of product modifications that are a logical outcome of the Toronto experience and that would be appropriate for the cost/quality requirements of a local market.

ii) Experience of bidding procedures.

The decision regarding the best method of bidding a systems building programme for British Columbia will depend upon the size of programme that has been organized and the extent of innovation and development that industry will be prepared to undertake for that market.

At the time of writing, the S.E.F. programme in Metropolitan Toronto had just signed contracts with the successful sub-system tenderers, and the R. A. S. programme in Montreal has just committed 2-1/2 million square feet of school space to the systems approach.

- The S. E. F. programme induced 36 companies to bid for a proportion of a $40 million market. Each participating sub-system supplier/manufacturer submitted a bid to meet the architectural performance specifications for the 32 schools comprising the building programme. The bidders were required (mandatory) to ensure that the products they bid had face-to-face compatibility with other designated sub-systems performing different functions. Four schools were nominated for the purpose of providing bidders with representational examples of the various design approaches which might be met across Metropolitan Toronto. Each bidder submitted a lump sum bid for the four nominated schools and supplied a unit price based upon the designated quantity for the rest of the programme. It should be pointed out that the bid was for all work described in the sub-system specifications (i.e., supply and fix) so that many manufacturers sublet various tasks within their own contract. In the case of some sub-systems the package is purely an administrative device (i.e., plumbing) and has no significance as a manufactured produce performing specific tasks. It is intended that each individual school within the Metropolitan programme will be designed, tendered and constructed following the traditional pattern but with a large proportion of the work pre-tendered by the nominated sub-system manufacturers. Consequently there will be a Management or General Contractor for each school building with the responsibility of completing site work and co-ordinating system components. The role of the Management or General Contractor is shifted to that of an agent working with predictable cost goals.

The overall effect of this approach was that each bidder established contact with a preferred series of other companies and submitted a base bid on the basis of the initial development work. Higher prices were submitted for the condition where products were less compatible with their own and consequently integration would be more costly. The approach allowed the Metropolitan School Board to designate successful bidders of the S. E. F. building system before the final technical integration was completed. The client nominally had the opportunity to choose from a possible 13,000 building systems ranging in price from $17.88 per square foot to $26.60 per square foot gross, less site work. The criteria which determined the final choice were a combination of cost, quality and performance considerations that assured that the client received the best value of his money in terms of the tasks to be performed. The final contracts were awarded on completion of the technical development and testing of the Eastview school addition. It is argued by some participants that by keeping bidding open to this point the approach is inhibiting technical innovation. The point being that the terms of reference necessary to allow for any combination of manufacturers bids establishes arbitrary limits for some products or conversely that some technical types of solution could not meet the performance specifications without costly modifications. Certainly the R.A.S. programme in Montreal has produced the possibility of a variety of well considered building systems which are a product of more extensive development work between a smaller group of manufacturers at an earlier stage. However, some manufacturers felt penalized by this method because their success depended upon the overall effectiveness of their own particular closed system and consequently the competence of other members of the group. The long term penalties of a proliferation of closed building systems is discussed elsewhere in this report. The logical outcome of the eastern Canada bidding experience to date is to develop a bidding method which combines the best features of both approaches as far as the manufacturers are concerned, while keeping the flexibility of the open system approach for the client.

iii) Cost goals and the "Construction Cost Index".

a) Cost goals of the bidding programme.

A major consideration in implementing a bulk buying programme is to ensure that in reality substantial cost savings are achieved. A direct comparison with a similar type of product will give a rough indication as to whether the bidding is achieving its intended purpose. In the case of the S. E. F. programme the "Metropolitan Toronto School Board Ceiling Cost Formula" for elementary schools was used as an index for comparison and a goal of ten percent less than the index was established for the bulk buying programme. The cost formulae was arrived at by an in depth analysis of costs of traditionally built elementary schools which had features similar to the proposed building system. These figures were published as part of the introductory documents to the S. E. F. programme so that the cost quality and performance goals were firmly established by the client at the commencement of the bidding process. The S. E. F. programme is scheduled to take three and a half years from the sub-system tender close to final component installation, so that a means of determining escalation of product and wage costs was developed by the S. E. F.

staff researchers. The construction cost index was also used to update the original 1967 cost goals to the January 1969 bidding date.

b) Construction cost index.

The inevitable time lag of a systems building programme between the submission of sub-system tenders and the installation of the last components implies that an equitable means must be found to recompense successful bidders who are faced with product and wage increases that occur during the implementation of the programme. The extensive response by industry to the S. E. F. programme and the subsequent establishment of the first open building system in Canada depended upon an equitable basis for competitive bidding being established particularly in light of the development work for manufacturers implicit in the programme. The resolution of cost escalation problems by establishing a "Construction Cost Index" reduced the unknowns in the bidding procedures to a reasonable level. A construction price index is published every month by S. E. F. indicating the percentage of cost increases for each sub-system that occurred during that month. The sub-system supplier is paid the percentage increase indicated by the scale at the completion of his particular work on the individual school.

The construction price index is the product of two components, a material cost scale and a wage scale combined by S. E. F. economic consultants on a weighting system established in consultation with members of the building industry. The Dominion Bureau of Statistics supplies information on the material cost scale and the Toronto Fair Wages Board supplies up to date information on current wage agreements.

There is no doubt that this particular form of construction cost index represents a useful innovation and is a technique which is an essential part of the system approach. However, the definition and application of the construction cost index will have to be modified to answer these two questions:

Who actually gets the benefits of productivity increases?
Is the weighting system of product and wage cost relevant to system methods? (i.e., the ratio established by S. E. F. must necessarily be based upon experience in traditional building).

It is not clear if the productivity gains made by the S. E. F. system will in fact be shared equitably by the client and manufacturer. The published cost per square foot for each sub-system indicates that the initial costs were reasonably near the original cost goals (8.39% actual and 14.24% possible of the updated Ceiling Cost Formulae). It was well known by sub-system bidders at the close of tenders in January 1969 that a number of major wage scale contracts were up for renewal in the summer of 1969. Consequently the allowance for this fact in the bids plus the application of the construction cost index may mean that productivity gains of the first S.E.F. system may accrue in a greater proportion to the sub-system suppliers than to the client. The tendering of the second and third programmes could be adjusted to overcome this possible inequity. Modifications of the technique need to be developed to ensure a reasonable division of productivity gain both to the client and the manufacturer in future systems programmes.

A re-evaluation of the weighting system for the construction cost index can be achieved by adjusting the relative values of finished product and labour from experience gained from the first S.E.F. programme. It is unlikely that the original ratio will continue to reflect a true ratio bearing in mind that one of the purposes of system building is to reduce site labour. Further empirical evidence must be accumulated in order to ensure that the weighting system reflects system building methods rather than the high proportion of site labour in traditional building.

iv) Cost and quality standards with reference to the British Columbia market.

- The cost/quality characteristics of a building system are interdependent and are determined by establishing a programme with features appropriate to local/regional/social and economic levels.

The predicted average cost per square foot gross for the initial four schools in the S.E.F. programme is $19.40. An overall saving of 8.39% is assured for the whole programme with the possibility of increasing this saving to 14.24% using the most efficient school designs possible with the designated sub-systems.

It is not reasonable or reliable to make direct local cost comparisons with the S.E.F. programme because these prices reflect a major quality improvement for schools in Metropolitan Toronto. Essentially the schools built with the S.E.F. building system will have high internal flexibility combined with high quality lighting and atmosphere control at an estimated saving of 30% if traditional construction methods had been used.

It is outside the terms of reference of this study to determine what are acceptable educational and building standards for a system building programme in British Columbia. Consequently it is concluded that an assessment of the cost/quality characteristics of the S. E. F. building system must be undertaken prior to the sponsorship of a building system locally in order to establish the degree of direct applicability of the S. E. F. system building components. The findings of such a study must establish the extent to which educational specifications and the cost/quality features of the S. E. F. building system are relevant to and consequently applicable to the school building programme in British Columbia.

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Activity Data Method - a method of recording user requirements.

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